NHTSA's 2005 ESC Research Program:
A Cooperative Effort

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Program Objectives

Collaboratively gather data to validate and refine NHTSA's proposed ESC identification criteria

Test Vehicles
(First Priority)

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Make	Model	Classification	ESC Availability
BMW	M5	High Performance Passenger Car	Standard
Cadillac	STS	Large Passenger Car	Standard
Chrysler	300 Limited	Large Passenger Car	Standard on all but base model
Mercedes	E-Class	Medium Passenger Car	Standard
Lincoln	LS	Medium Passenger Car	Optional
Porsche	911	High Performance Passenger Car	Optional
Scion	xB	Small Passenger Car	Standard
Subaru	Outback	Medium Passenger Car	Optional
Dodge	Sprinter	Van	Standard on some models
Ford	Freestar	Minivan	Optional
Pontiac	Montana SV6	Minivan	Optional on front-wheel drive model
Nissan	Frontier	Pickup	Optional
Toyota	Tacoma	Pickup	Optional
Toyota	Tundra	Pickup	Optional
Chevrolet	Avalanche	SUV	Standard for MY2005
Chevrolet	Suburban	SUV	Standard for MY2005
Jeep	Grand Cherokee 4x4	SUV	Optional
Honda	CR-V 4x4	SUV	Standard
Mitsubishi	Montero	SUV	Standard
Volkswagen	Touareg	SUV	Standard

Test Vehicles (Second Priority)

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Passenger Cars

Make	Model	Classification	ESC Availability
Acura	RL	Medium Passenger Car	Standard
Acura	TSX	Medium Passenger Car	Standard
Audi	A4 (AWD)	Medium Passenger Car	Standard
BMW	525i	Medium Passenger Car	Standard
BMW	Z4	High Performance Passenger Car	Standard
Buick	LaCrosse CXS	Medium Passenger Car	Optional
Cadillac	XLR	High Performance Passenger Car	Standard
Infinity	Q45	Large Passenger Car	Standard
Lexus	ES330	Medium Passenger Car	Standard
Mazda	RX-8	High Performance Passenger Car	Optional
Mercedes	SLK350	High Performance Passenger Car	Standard
Nissan	350Z	High Performance Passenger Car	Optional
Pontiac	Vibe	Small Passenger Car	Optional
Porsche	Boxster	High Performance Passenger Car	Optional
Saab	9-3	Medium Passenger Car	Standard
Toyota	Corolla	Small Passenger Car	Optional on "S" and "LE" models

Minivans, Pickups, and SUVs

Make	Model	Classification	ESC Availability
Honda	Odyssey	Minivan	Standard for MY2005
Nissan	Quest	Minivan	Optional
Toyota	Sienna	Minivan	Optional
Nissan	Titan	Pickup	Optional
BMW	X3	SUV	Standard
Ford	Explorer 4x4	SUV	Standard for MY2005
Hummer	H2	Large SUV	Standard for MY2006
Hyundai	Tucson	SUV	Standard
Infinity	QX45	Large SUV	Standard
Kia	Sportage	SUV	Optional
Land Rover	Land Rover	SUV	Standard
Lexus	RX330	SUV	Standard
Mercedes-Benz	M-class (MY2006)	SUV	Standard
Nissan	Armada	SUV	Optional

Five Maneuvers
Performed With A Steering Machine

- **Slowly Increasing Steer** *(for characterization use only)*
- **0.7 Hz Sine with Dwell**
- **0.7 Hz Increasing Amplitude Sine**
- **500 deg/s Yaw Acceleration Steering Reversal**
- **500 deg/s Yaw Acceleration Steering Reversal w/Pause**

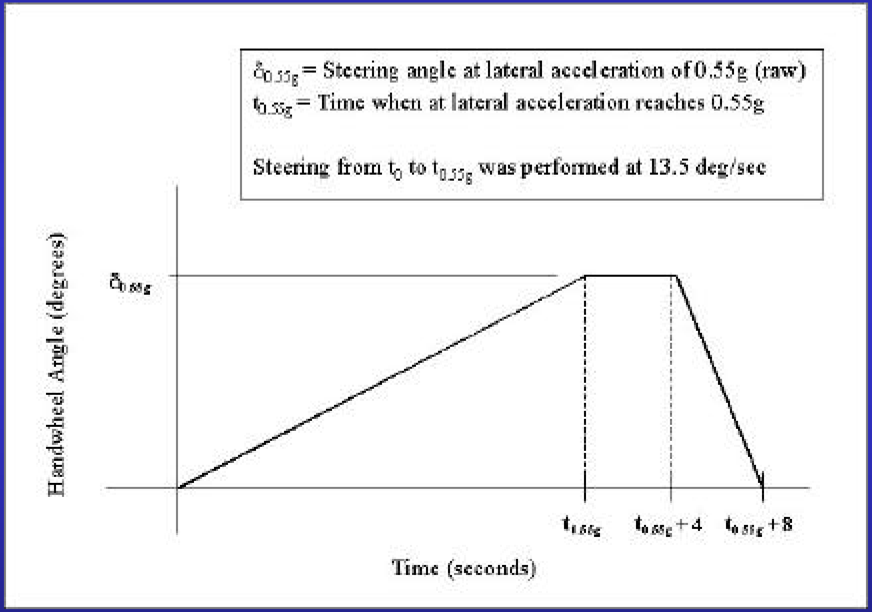
Test Conditions

- ESC enabled and disabled
- Test surface
  - Dry, high-mu asphalt
  - Maneuvers initiated while vehicle is being driven up a 1% grade
- Nominal load
  - Driver
  - Instrumentation
  - Outriggers if vehicle is an SUV, pickup, van, minivan, station wagon, or crossover vehicle

Maneuver Description

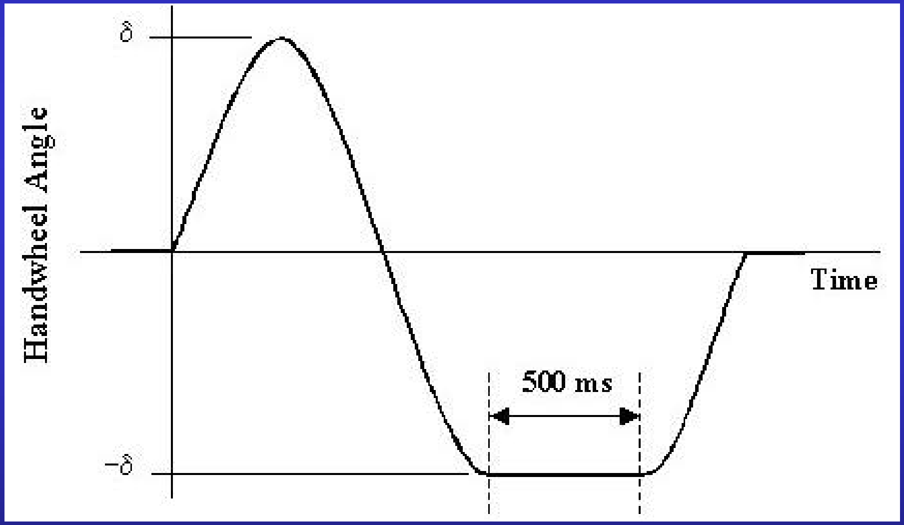
Slowly Increasing Steer

- **Low severity**
  - **Used for characterization only**
  - **Raw AY of 0.55g**
- **Provides the SWA at 0.3g**
  - **Data is required by all other maneuvers performed in this study**
  - **Must first be corrected for roll effects**
- **Driver attempts to maintain constant vehicle speed via throttle modulation**
  - **50 mph**



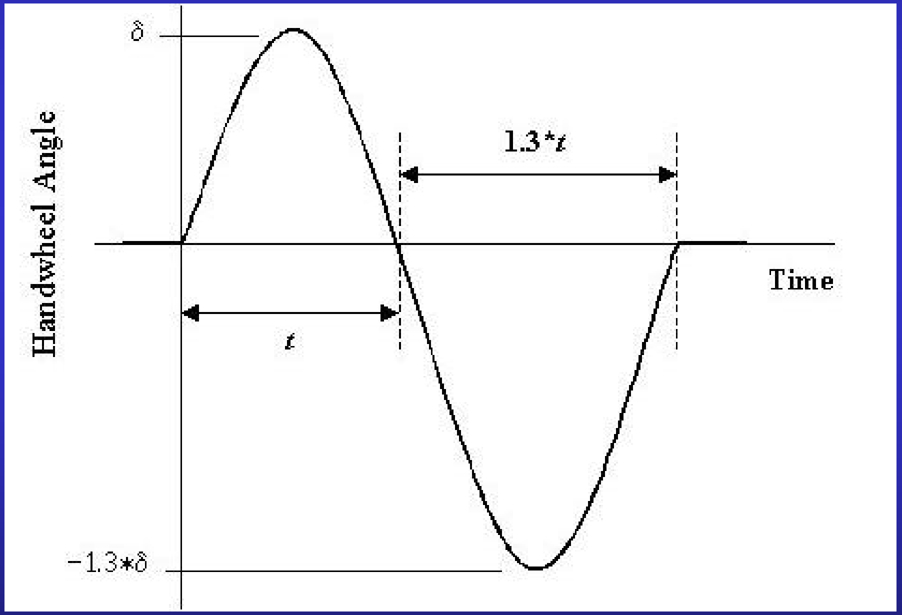
Maneuver Description
0.7 Hz Sine with Dwell

- **Steering frequency fixed at 0.7 Hz, but with a 500 ms pause after the 3rd quarter-cycle**
- **Severity increased with SWA**
  - **45-deg increments**
  - **Lowest SWA: 45 deg**
  - **Highest SWA: 270 deg or 6.5*$d_{0.3g \text{ AY from SIS}}$, whichever is greater**
- **50 mph entrance speed**
- **Dropped throttle**



Maneuver Description
0.7 Hz Increasing Amplitude Sine

- Steering of frequency first ½ cycle fixed at 0.7 Hz
- 2nd ½ cycle amplitude is 1.3 times that of the 1st ½ cycle
- Duration of the 2nd ½ cycle is 1.3 times that of the 1st ½ cycle
- Severity increased with SWA
  - 45-deg increments
  - Lowest SWA: 45 deg
  - Highest SWA: 270 deg or 6.5*d$_{\text{0.3g AY from SIS}}$, whichever is greater
- 50 mph entrance speed
- Dropped throttle



Maneuver Description
Yaw Acceleration Steering Reversal

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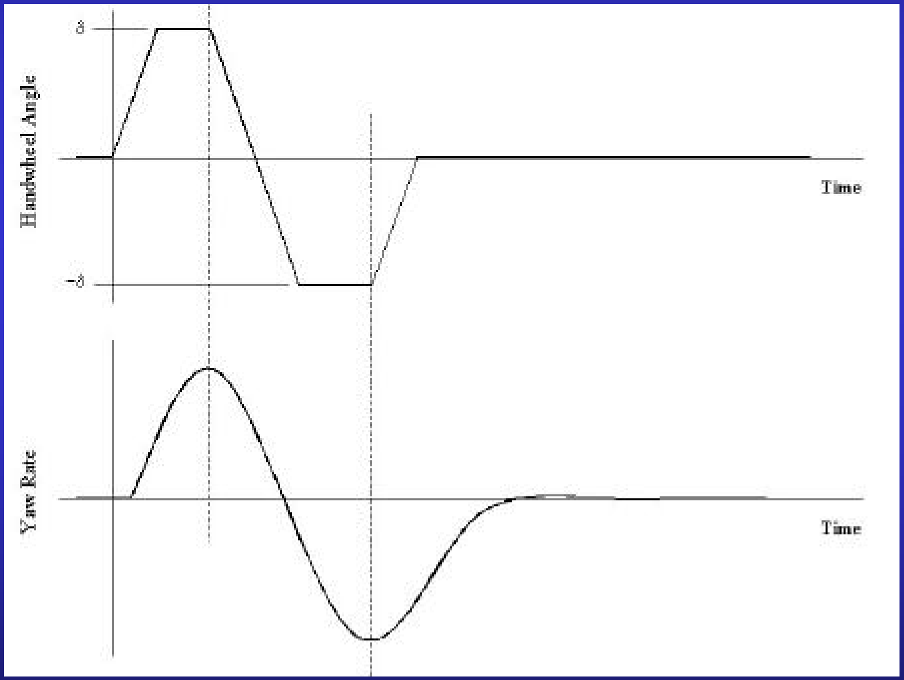
- **Maneuver adapts to the vehicle being evaluated rather than relying on one frequency**
- **Steering reversals both initiated at peak yaw rate**
- **Severity increased with SWA**
  - **45-deg increments**
  - **Lowest SWA: 45 deg**
  - **Highest SWA: 270 deg or 6.5*$d_{0.3g\ \text{AY from SIS}}$, whichever is greater**
- **500 deg/s ramp rates**



Maneuver Description
Yaw Accel Steering Reversal w/Pause

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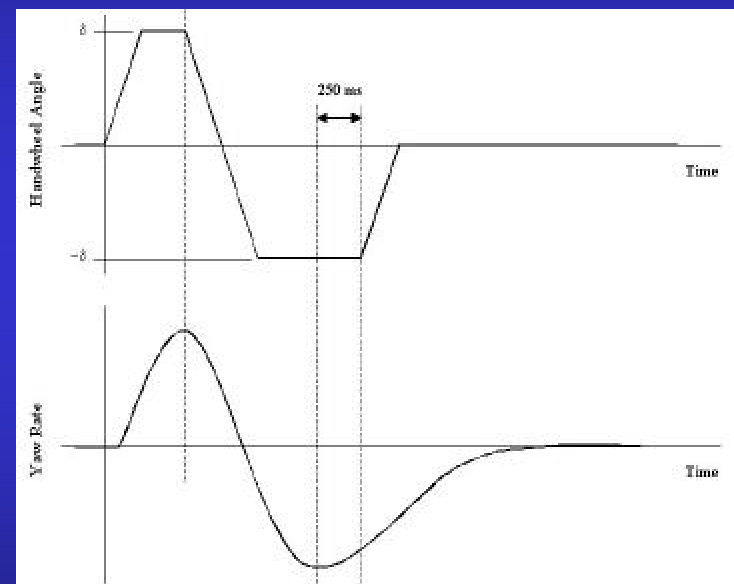
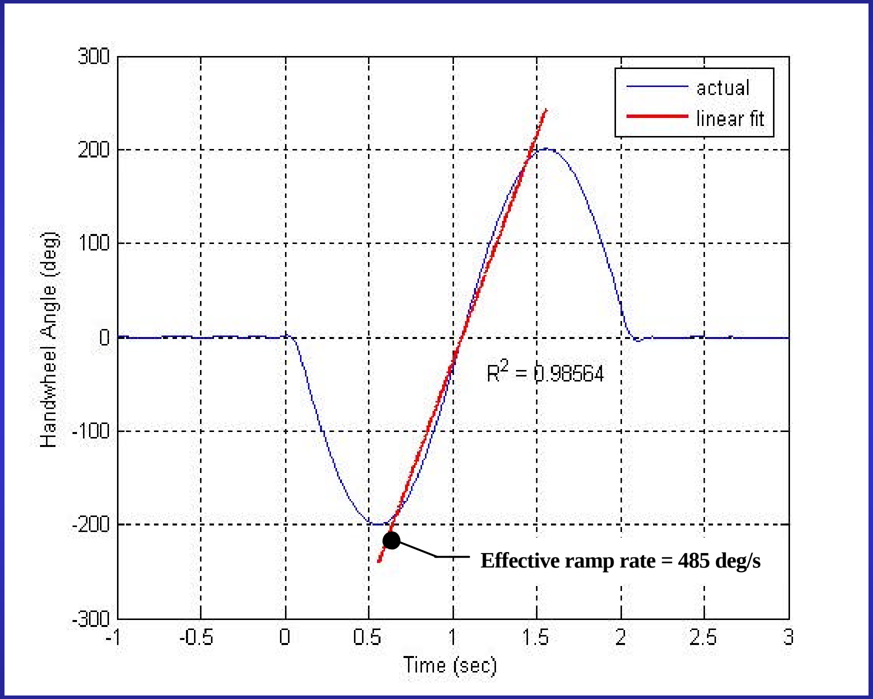
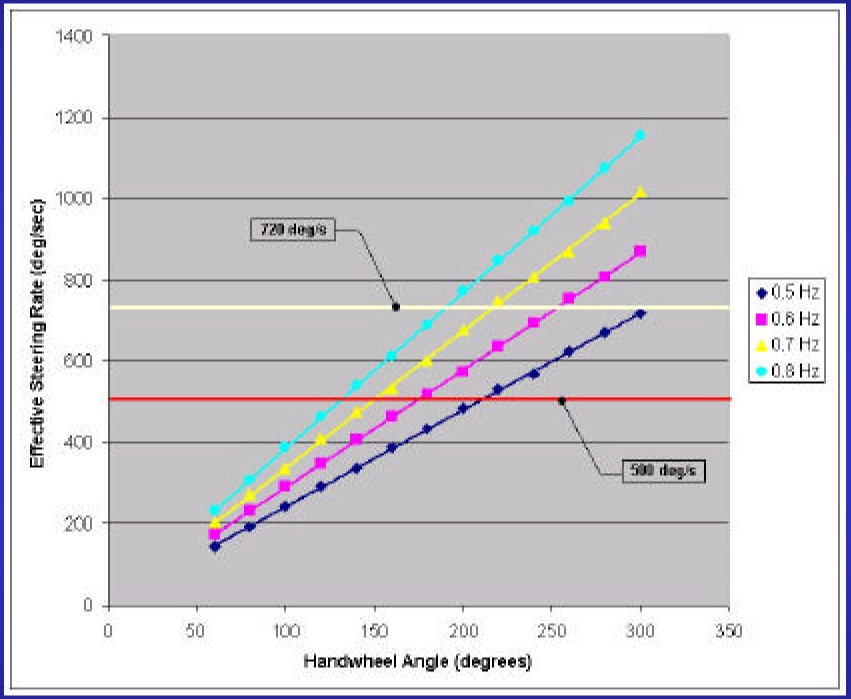
- **Maneuver adapts to the vehicle being evaluated rather than relying on one frequency**
- **1st steering reversal initiated at peak yaw rate, 2nd reversal at peak yaw rate + 250 ms**
- **Increased dwell after second yaw rate peak gives the vehicle more time to respond to the second peak SWA**
- **Severity increased with SWA**
  - **45-deg increments**
  - **Lowest SWA: 45 deg**
  - **Highest SWA: 270 deg or 6.5*$d_{0.3g\ AY\ from\ SIS}$, whichever is greater**
- **500 deg/s ramp rates**



Conceptual Comparison
Effective Sine Steer Rates





0.5 Hz Sine Steer, SWA = 200 degrees

Question: *Should the "ESC identification maneuver" be comprised of increasing steer angles and constant rates (e.g., 500 deg/sec Yaw Acceleration Steering Reversal) or increasing rates (e.g., 0.7 Hz Sine with Dwell)?*

Direction of Steer

- Left-right tests precede those performed with right-left steering
  - 0.7 Hz Sine with Dwell
  - 0.7 Hz Increasing Amplitude Sine
  - 500 deg/s Yaw Acceleration Steering Reversal
  - 500 deg/s Yaw Acceleration Steering Reversal w/Pause
- Slowly Increasing Steer
  - Three left steer tests, followed by three right steer tests

What is a "Spinout"
Preliminary Definition

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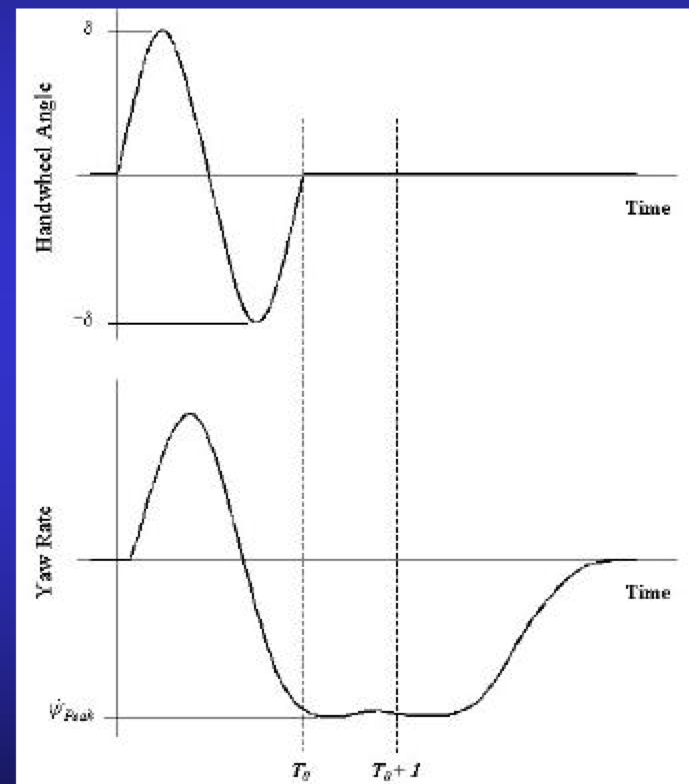
$$Percent\ \dot{y}_{Peak} = 100 * \left(\frac{\dot{y}(t)}{\dot{y}_{Peak}} \right)$$

$$Set\ t = t_0 + 1$$

$$Spinout\ occurs\ if\ \ Percent\ \dot{y}_{Peak} \geq 60\%$$



Requested Data

- **For each test performed:**
  - Final heading angle (with respect to initial path)
  - Percent of peak yaw produced at t_0 + 1.0
  - Maximum lateral displacement produced
  - Longitudinal displacement from initiation of steering input to maximum lateral displacement
  - Was two-wheel wheel lift observed?
- **Maximum steering wheel angle**
- **Data from “First Priority” vehicles desired by May 16, 2005**

Key Points

- **ESC research is a top priority for NHTSA**
- **A cooperative testing effort between NHTSA and industry is proposed**
- **Test data from industry-evaluated vehicles is requested**
  - **Data will help determine the most efficient maneuver capable of determining whether a vehicle is equipped with an ESC**
  - **Used to improve the robustness of its spinout model**
  - **Will help assess lateral displacement capability of ESC-equipped vehicles**